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Treatment of landfill leachate in membranes bioreactor with yeast (Saccharomyces cerevisiae)

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INTRODUCTION

The landfill leachate is complex and presents high pollution potential. Its composition depends mainly on the characteristics of the waste deposited, hydroclimatological conditions and especially on the age of the landfill. In general, presents high organic load, high concentration of ammonia and may contain various toxic compounds such as heavy metals and aromatic hydrocarbons.

The spatial and temporal variation of leachate difficult the treatment process. Old landfill leachate have a high content of recalcitrant organic matter, resulting in a low ratio BO BOD5/COD. According to Ahmed and Lan (2012) membrane bioreactor (MBR) are particularly advantageous in the treatment of landfills leachate, once they can increase the biodegradability of refractory compounds and micropollutants, allowing high solids retention times. However, according to a literature review, several authors showed that a COD removal ranged from 23 to 90%, mainly due to the age of the leachate, and the operating conditions employed.

The biomass of bioreactor typically consists of bacterial microorganisms, but this group may have limitations for the degradation of refractory organic compounds of the leachate. In contrast, fungi and yeasts have high capacity of breaking and assimilating difficult degradation pollutants. Several genera of yeast (*Candida, Rhodotorula, Yarrowia, Hansenula, Saccharomyces*) have been described as able to degrade complex organic compounds (HARMS *et al*., 2011). The application of this microbial group in the treatment of wastewater has been tested in the last decades, where high efficiencies of treatment process were observed (DAN *et al*., 2002).

Thus, the use of MBR inoculated with a yeast biomass, can be effective in the treatment of landfills leachate, with high concentrations of recalcitrant compounds. The objective of this study was to evaluate the performance of an MBR inoculated with biomass of *Saccharomyces cerevisiae* (baker's yeast) in the treatment of landfill leachate.

METHODOLOGY

The leachate, after pretreatment of stripping of ammonia, from a landfill in southeastern Brazil was used. The main characteristics of leachate are shown in Table 1:

:Parameters	Mean Values
Color (uH)	2086
COD (mg/L)	3942
BOD (mg/L)	207
BOD_5/COD	0,06

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Ph	8,46
Humic Substances (mg/L)	2565
TKN (mg/L)	2163
NH_3-N (mg/L)	1529
Chloride (mg/L)	2749
Total Solids (g/L)	9,7

The MBR used have a submerged microfiltration module, consisting of hollow fiber membranes of poly(ether-imide). The module has a 0, 04 m^2 area, and a 0,5 µm maximum pore size. The hydraulic permeability of the membrane, measured with microfiltered water was 298 L/h.m^2.bar. In the operation of the MBR, first, S. cerevisiae has undergone a step of acclimation, which was a gradual increase in the concentration of leachate (20, 40, 60, 80 and 100%) and reduction in the concentration of Sabouraud broth (3.0, 2.0, 1.0 and 0 g/L) in the feed. This step is terminated when the biomass reaching removal of COD greater than 70% with the feed being leachate in the concentration 100% without the addition of Sabouraud broth. The initial concentration of *S. cerevisiae* (baker's yeast lyophilized) was 10,000 mg/L.

The system was kept under aeration (1.0 Nm^3/h) at pH 3.5 and temperatures between 25 and 30°C. The flow and permeate flow was 0.2 L/h and 5 L/h.m^2 respectively, sufficient to maintain an HRT of 48 h, whereas a useful volume of the tank biological 9.60 L. Backwash was used with a flow of 0.5 L/h, every 15 min with duration of 15s. Aeration of the module was kept at a flow of 0.5 Nm^3/h, corresponding to an aeration rate of 12.5 $Nm^3/h.m^2$.

RESULTS

To date, the research is in the last phase of acclimatization (100% leachate with 1 g/L of Sabouraud broth). Thus, the results are related until this step. The expected completion of the operation of the MBR is 100 days. During the acclimation COD feed varied of 2239 to 8833 mg/L, considering the COD of Sabouraud broth, the color ranged from 746 to 12,879 mg/L. The efficiency of removal of color, COD and humic substances during the acclimation period can be observed in Figures 1, 2 and 3 respectively.

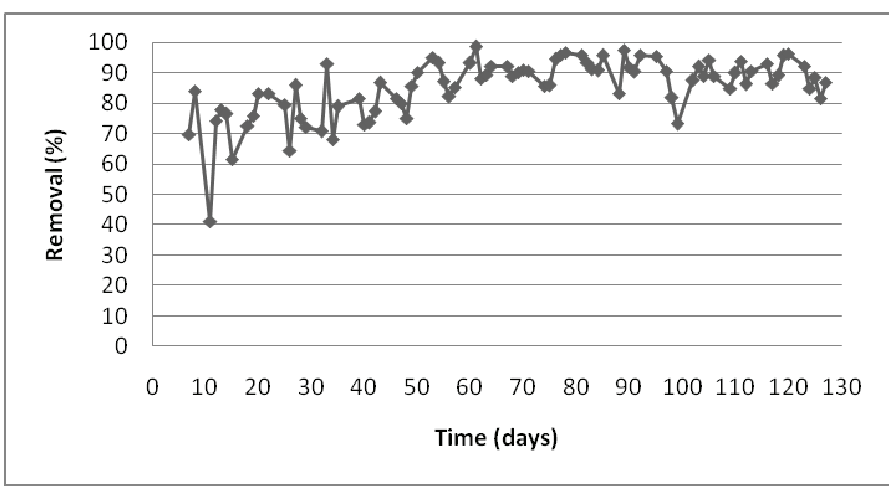

Figure 1: color removal efficiency

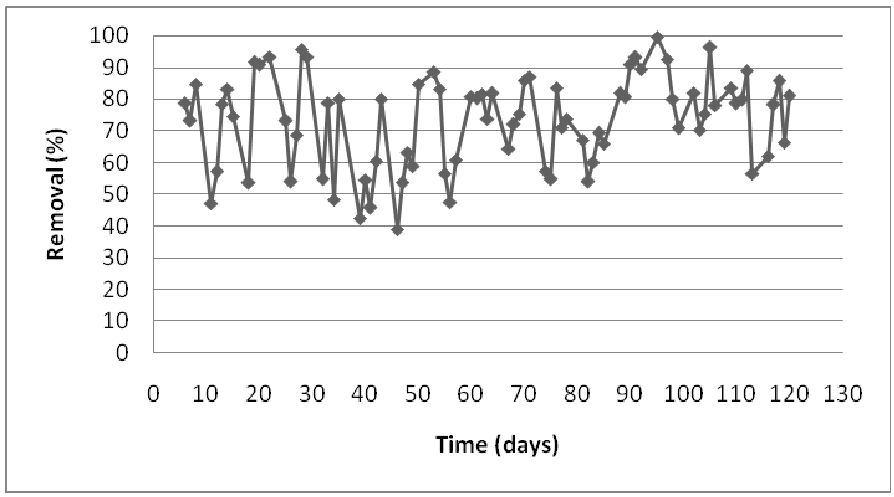

Figure 2: COD removal efficiency

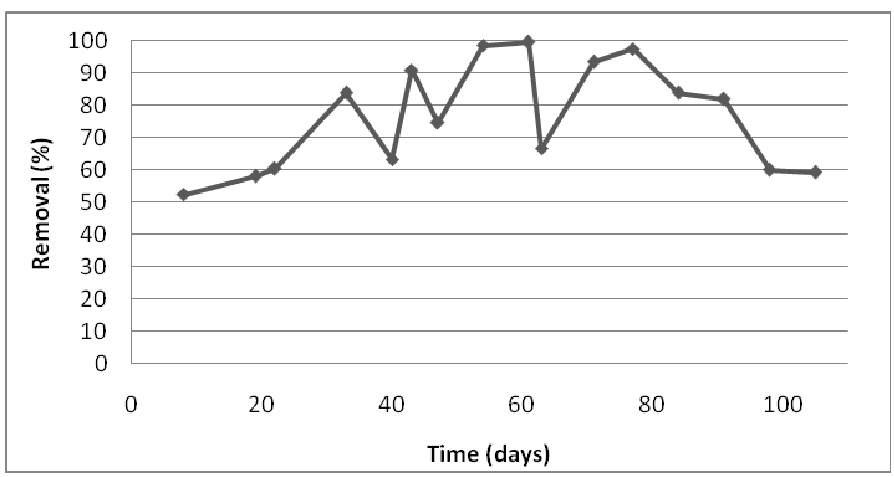

Figure 3: humic substances removal efficiency

The average efficiency of COD removal was 74.04%, color 82.08% and humic substances 67.17%. The permeate had a COD concentration range of 24 – 2,624 mg/L, the color ranged of 107 to 706 mg/L and humic substances of 4 a 331 mg/L. At the beginning the change in pH was high (2.5 to 9.5) subsequently reduced (3.0 to 4.0), where the adjustment being done to 3.5. The occurrences of low efficiency was attributed at the beginning, the high variation of the pH and after to operational problems, mainly related to deregulation of the permeate flow and aeration system.

MLSS concentration varied greatly along the acclimatization period, therefore, decided to use the technique of plating and the count of colony-forming units (CFU)/ml (TORTORA *et al*., 2003) for biomass production. There was intense contamination by wild filamentous fungi. The *S. cerevisiae* increased from 10^{10} CFU/ml to about 10^{13} CFU/ml in about 60 days. In the 25th day the concentration of fungi was 10^{08} CFU/ml and on 80th day rose to 10^{11} CFU/ml. Itis believed that the fungi have also contributed to remove COD from the leachate.

Regarding fouling of the membrane, there has been a good system performance. Figure 4 shows the variation of the TMP over time. From the 56th to the 85th day the increase in TMP was more frequent due to problems in the aeration module, which intensified fouling. Anyway, in general, the chemical cleaning, performed with NaOCl 2%, occurs approximately every twenty days.

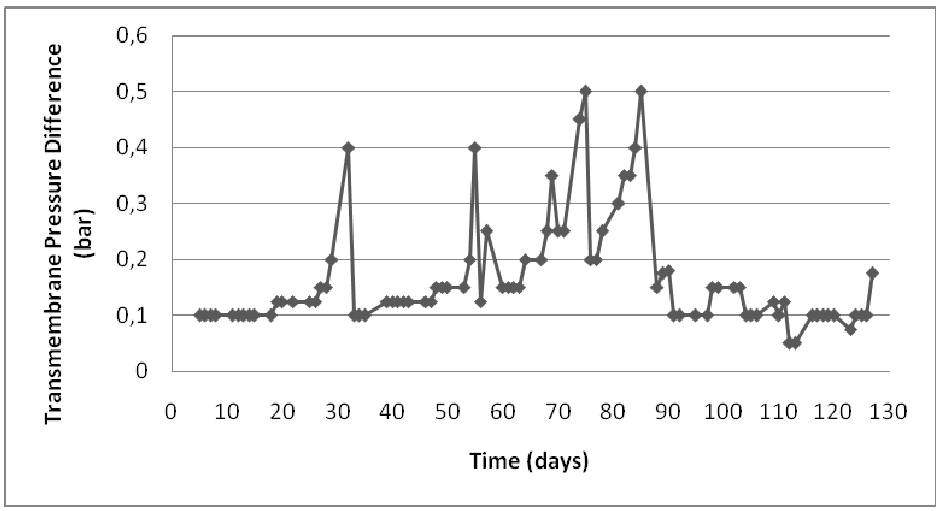

Figure 4: Variation of TMP

The average production of bound EPS and soluble EPS in terms of carbohydrates was 8.85 and 466.8 mg/L, respectively. In terms of proteins, the average concentration of bound EPS was 55.83 mg/L and of soluble EPS 562.14 mg/L.

These results agree with Dan *et al*. (2002) and Wichitsathian *et al*. (2004), which backed the use of MBR with yeast biomass for the treatment of effluents with high salinity and landfill leachate, respectively. The authors compared a MBR with yeast, enriched of the effluent itself, and another with bacteria, and observed that the MBR with yeast was more efficient in removing COD and demonstrated a lower rate of fouling, with low increase in TMP along the time and reduced production of EPS.

CONCLUSION

The results suggest a high efficiency of the proposed system for the treatment of landfill leachate with a high content of recalcitrant compounds.

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